Rock Slope Failure and Kinematic Analysis

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Rock Slope Failure

Location: British Columbia, Canada

https://en.wikipedia.org/wiki/Rockfall#/media/File:Rockfall.jpg

Rock Slope Failure

Location: Lauria, Italy Landslide type: Wedge failure

https://en.wikipedia.org/wiki/Landslide_classification#/media/File:Wedge_slide.JPG

Rock Slope Failure

Planes of failure

Location: Canada Landslide type: Rock Slide

https://en.wikipedia.org/wiki/Landslide_classification#/media/File:Mica_Dam_spillway.jpg

Rock Slope Failure

Location: Afton, Virginia along I-64

Rock Slope Failure

Rock Slope Failure

What is the common cause of slope failures shown above?

- Failure is along discontinuities
- Orientation of discontinuities controls failure

Kinematic Analysis

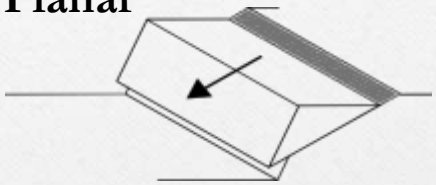
- Potential for global failure or releasing rockfalls
  - Dependent on discontinuity orientations

Types of Discontinuities

- Bedding
- Foliation
- Shear zones
- Fault planes

Kinematic Analysis

Planar

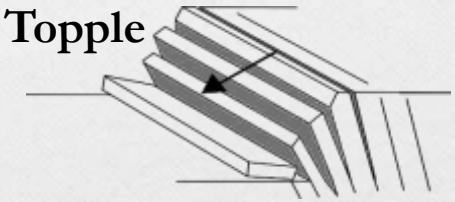


Planar failure where the discontinuity intersects the slope face

Wedge

Two discontinuities intersect and also intersect the slope face

Topple

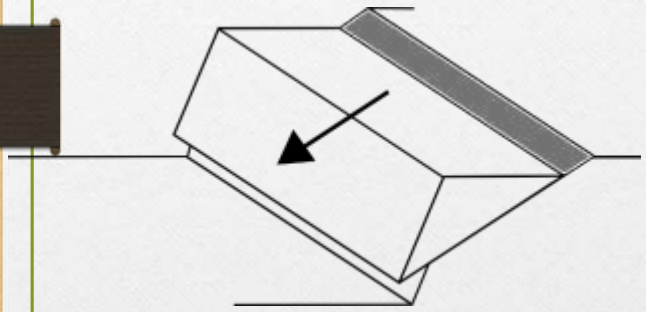


Steeply dipping discontinuities cause slabs and columns to separate from face

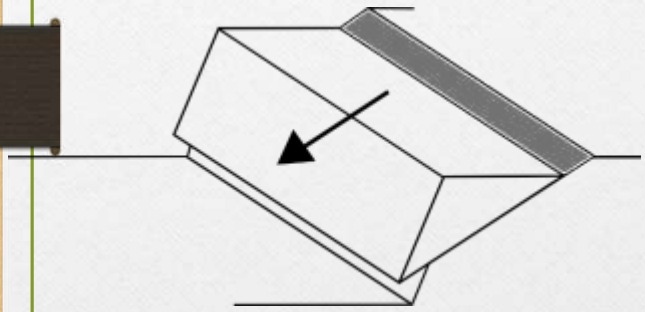
Circular

Circular failure in soil, waste or heavily fractured rock with no definable structural pattern

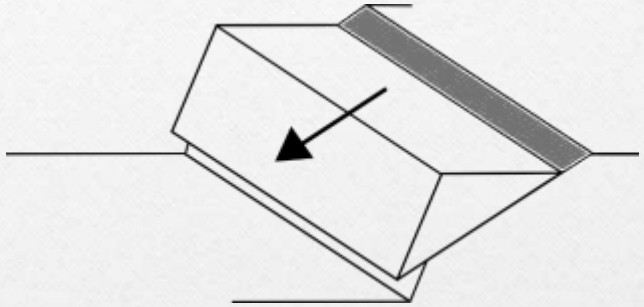
Plane Failure



Plane Failure

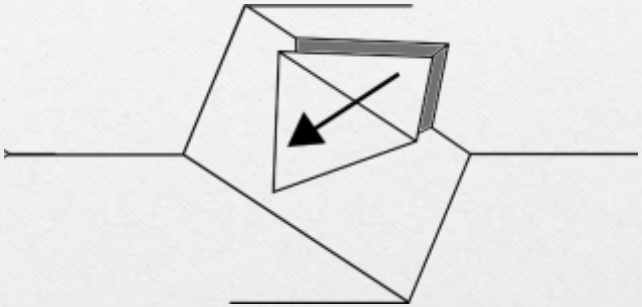


Plane Failure Criteria

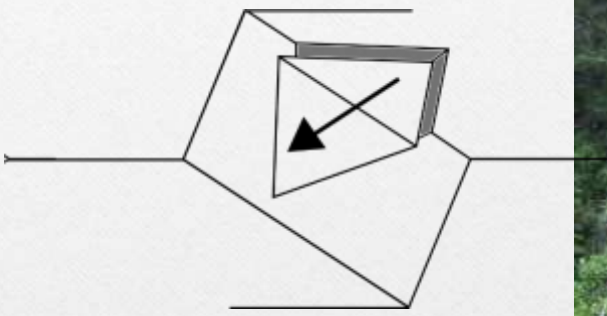


- Discontinuity should be parallel to slope face
- Discontinuity should dip at a gentler angle than slope face
- Discontinuity dip should be greater than friction angle

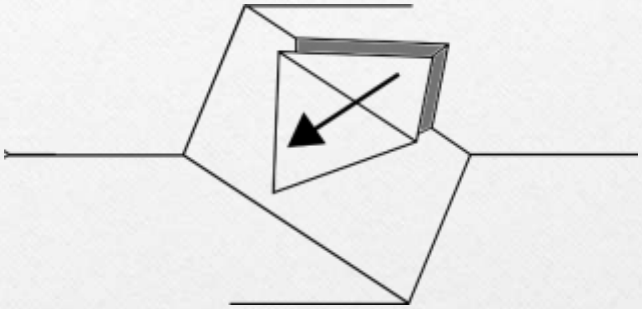
Wedge Failure



Wedge Failure

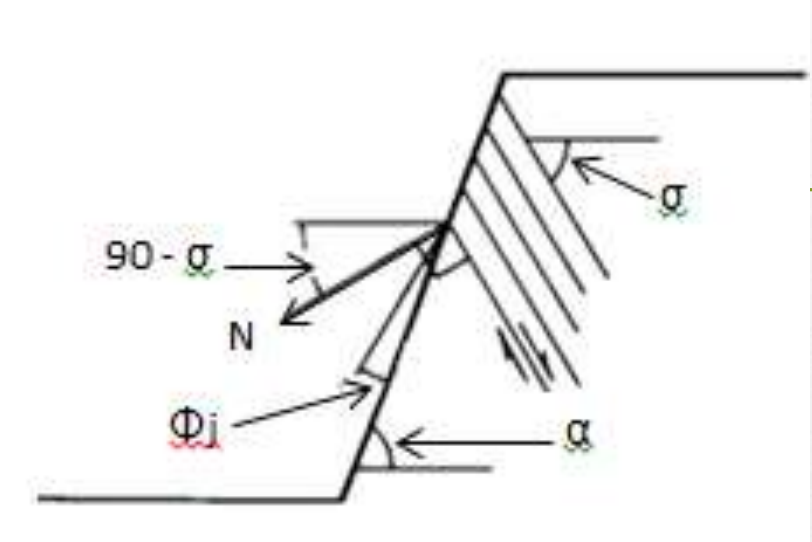


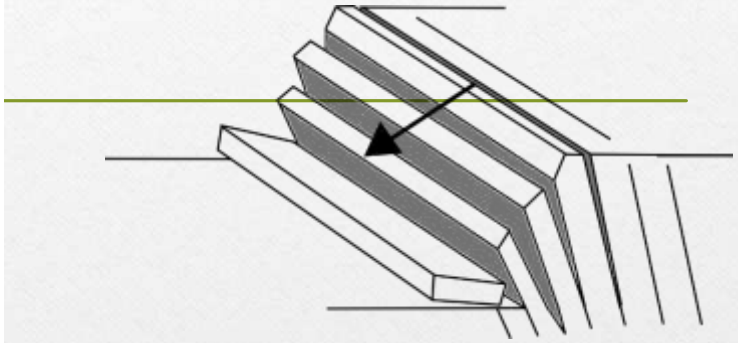
Wedge Failure Criteria



- Line of intersection should intersect the slope face
- Line of intersection should plunge at a gentler angle than slope face
- Line of intersection should be greater than friction angle

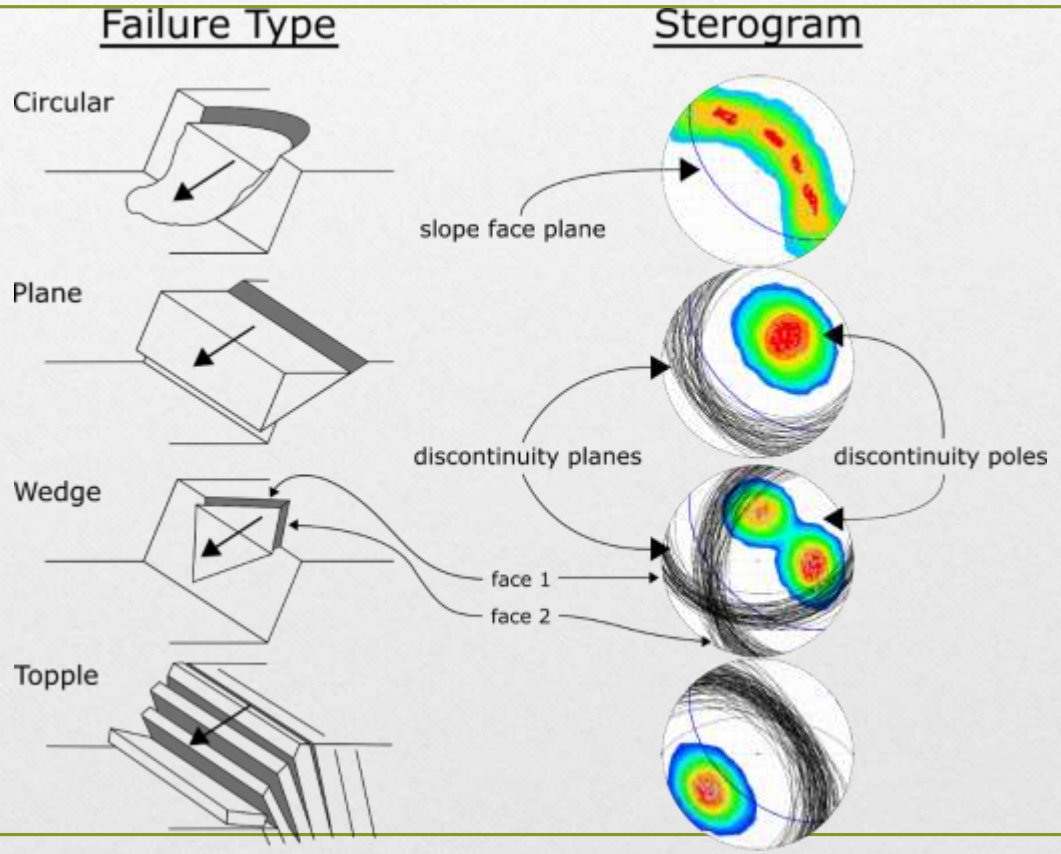
Toppling Failure Criteria





The kinematic requirement for toppling failures according to Goodman (1989) is: "If layers have an angle of friction Φj, slip will occur only if the direction of the applied compression makes an angle greater than the friction angle with the normal to the layers. Thus, toppling failure with a slope inclined α degrees with the horizontal and discontinuities dipping at σ can occur if $(90 - \sigma) + \Phi j < \alpha$".

Stereonet-Based Kinematic Analysis



Stereonet-Based Kinematic Analysis

Discontinuity Orientation Measurements

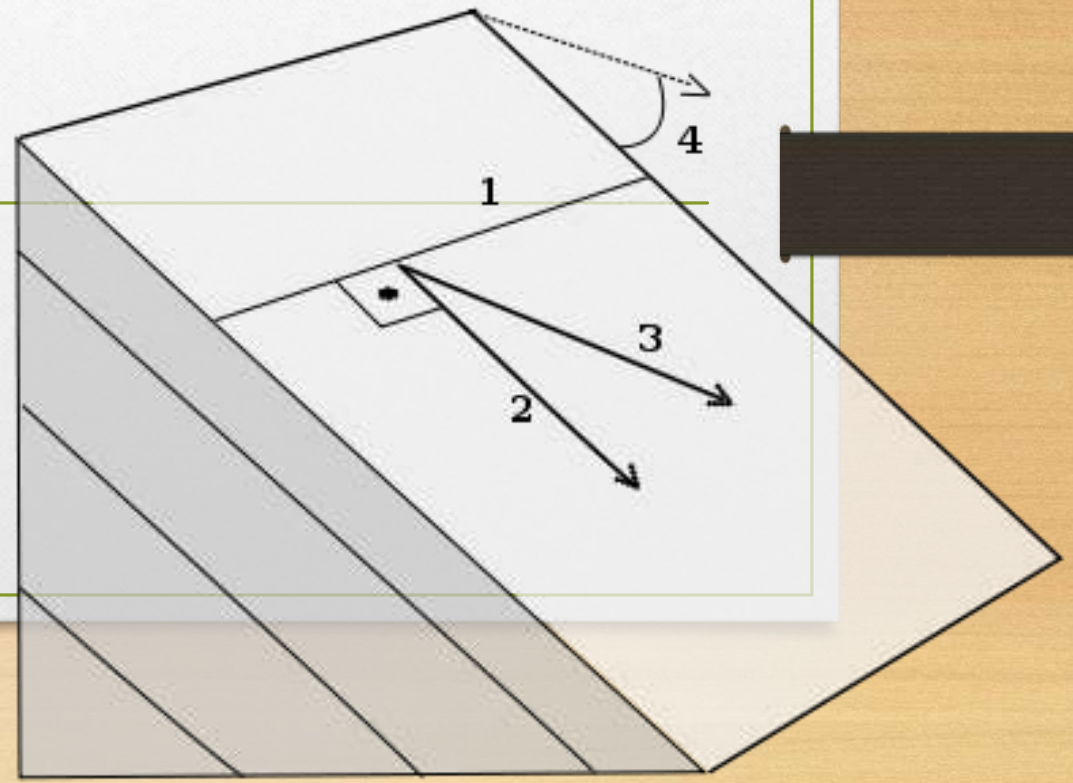
Strike and dip of the beds.

1-Strike

2-Dip vector

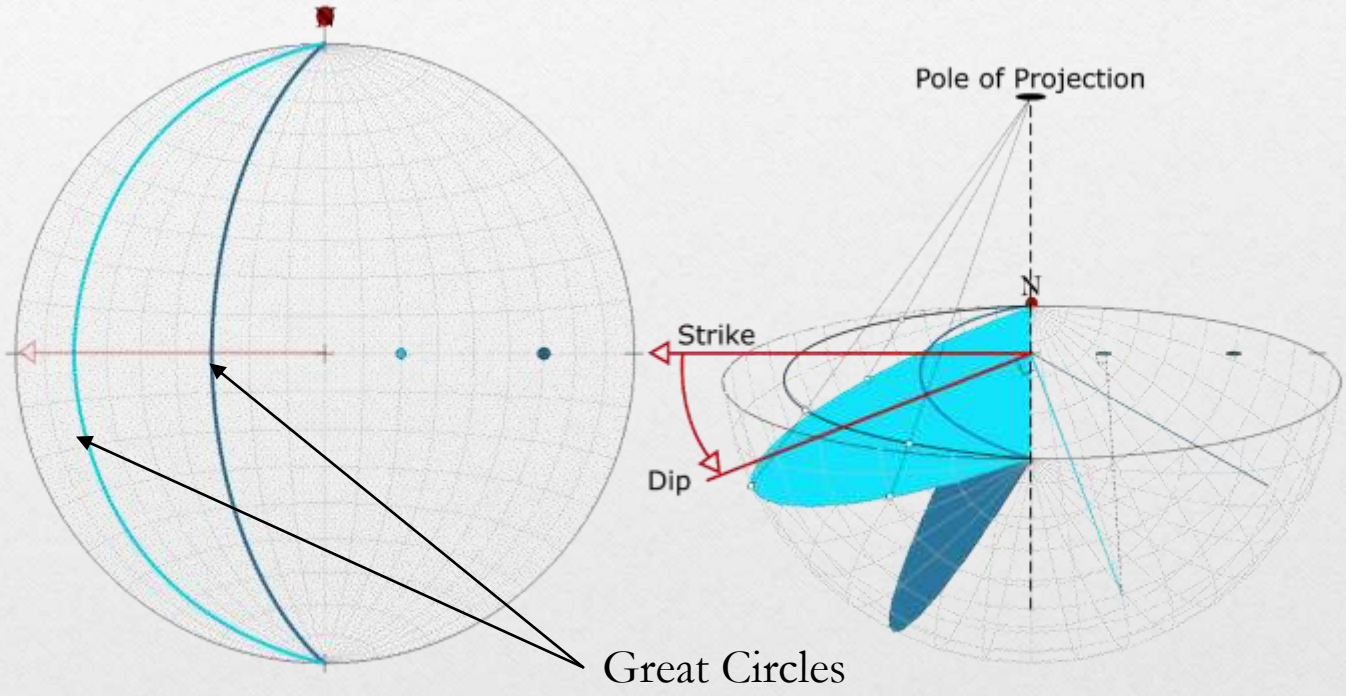
3- Dip direction

4-Angle of dip



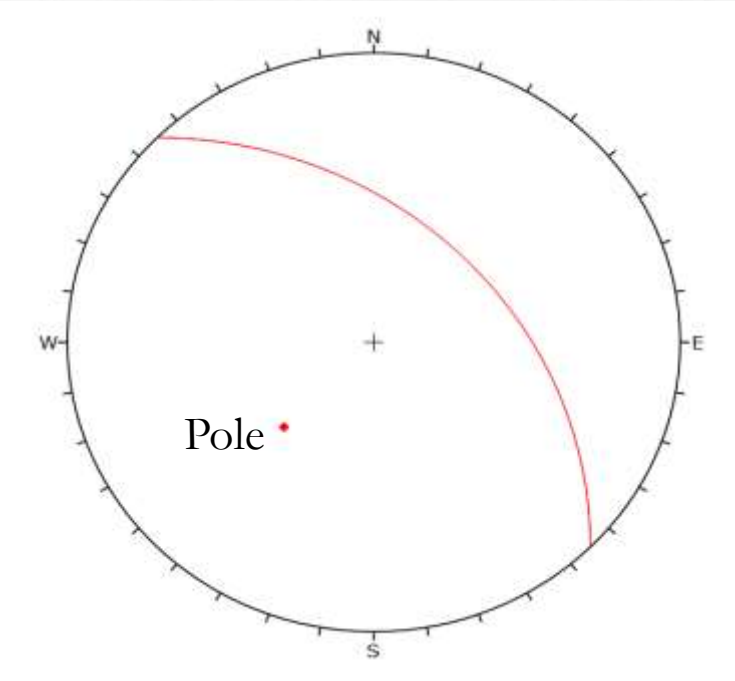
Stereonet-Based Kinematic Analysis

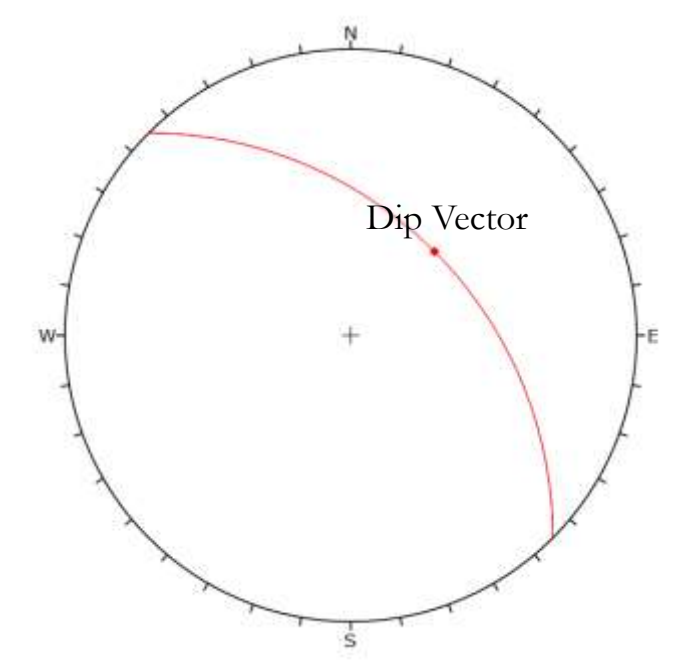
Discontinuity Orientation Measurements



Stereonet-Based Kinematic Analysis

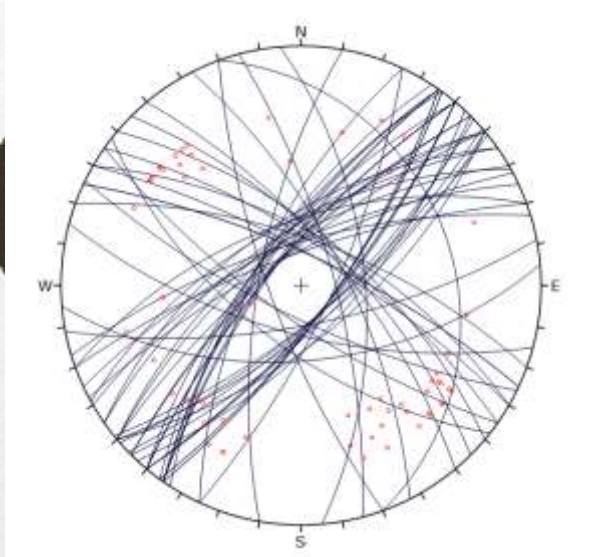
Plotting Discontinuity Orientation



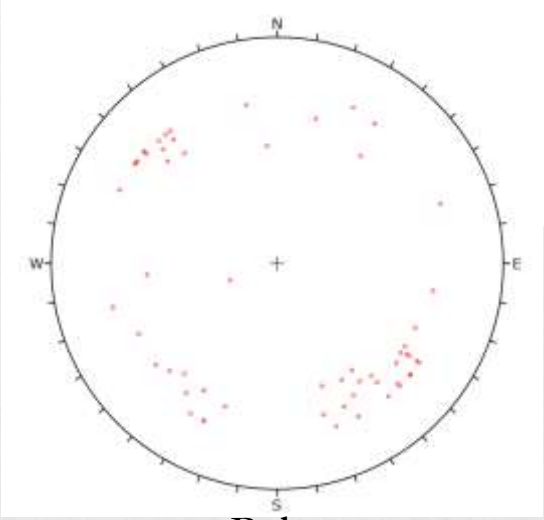


Stereonet-Based Kinematic Analysis

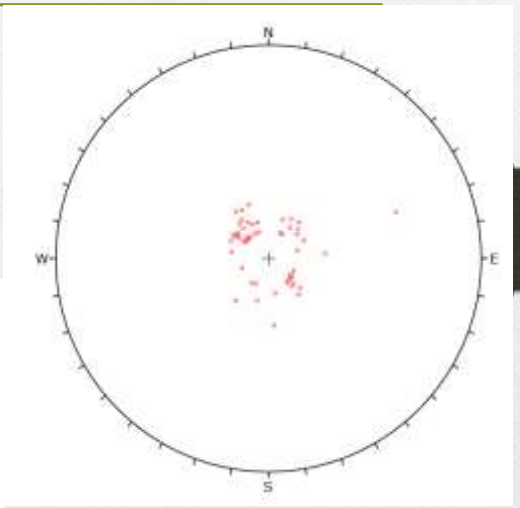
Plotting Discontinuity Orientation



Great Circles



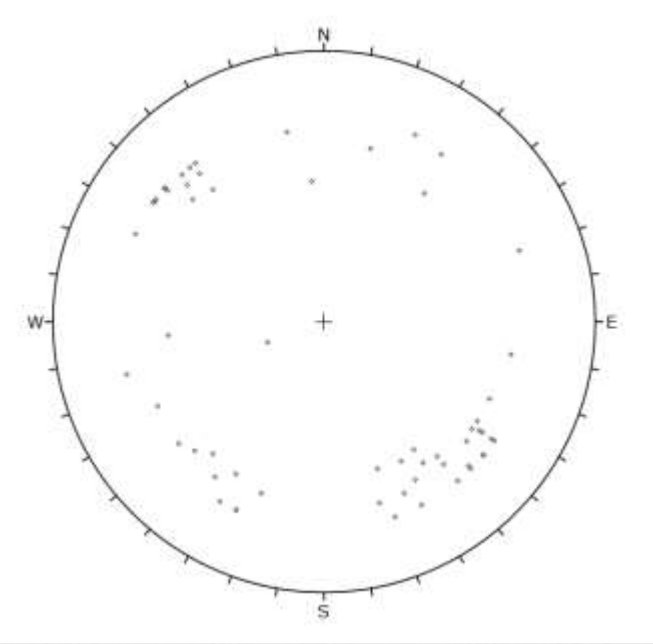
Poles



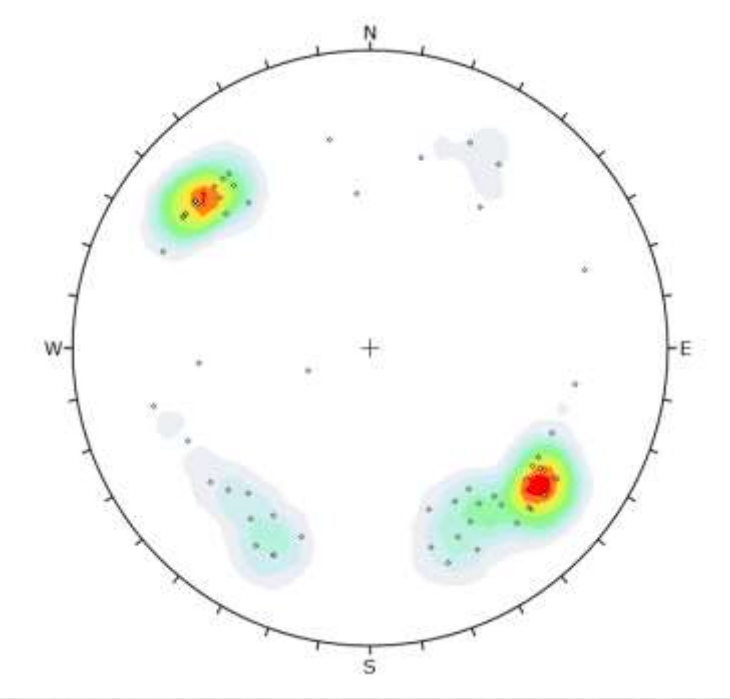
Dip Vectors

Stereonet-Based Kinematic Analysis

Plotting Discontinuity Orientation



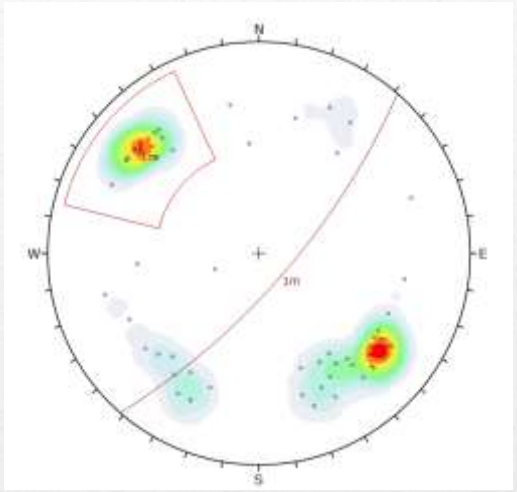
Poles

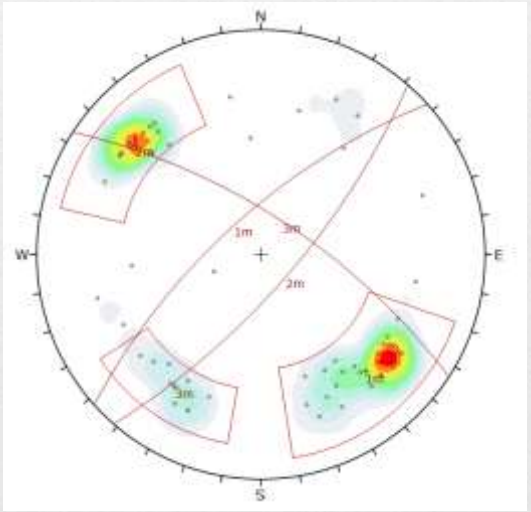


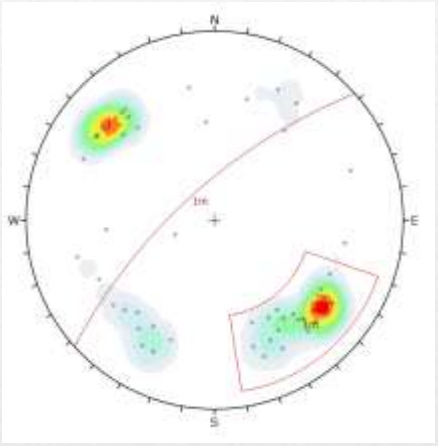
Contoured Poles

Stereonet-Based Kinematic Analysis

Identifying representative great circles using Dips software

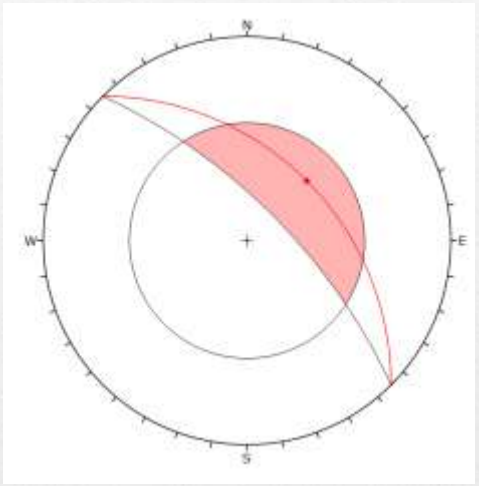




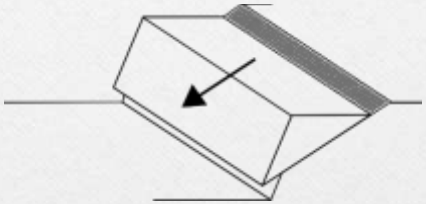


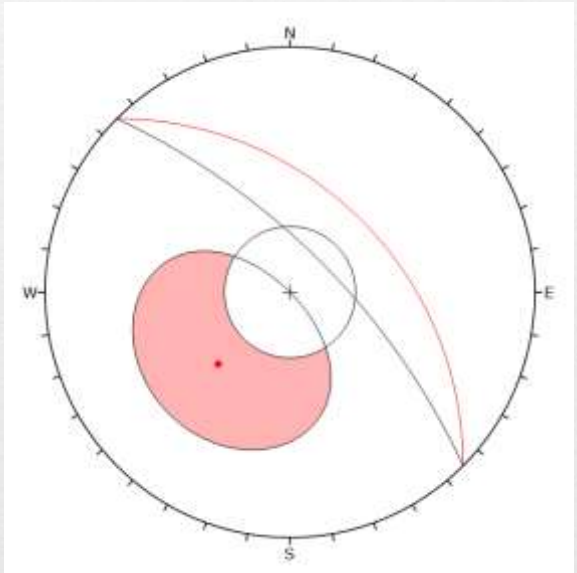
Stereonet-Based Kinematic Analysis

Plane failure criteria



Dip Vector

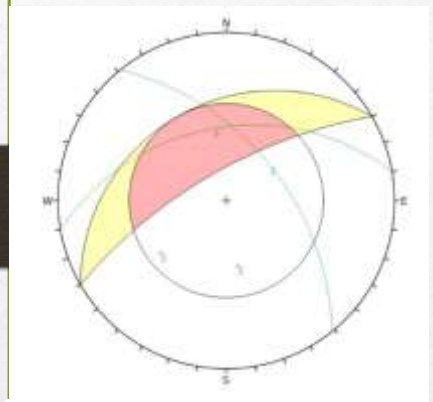


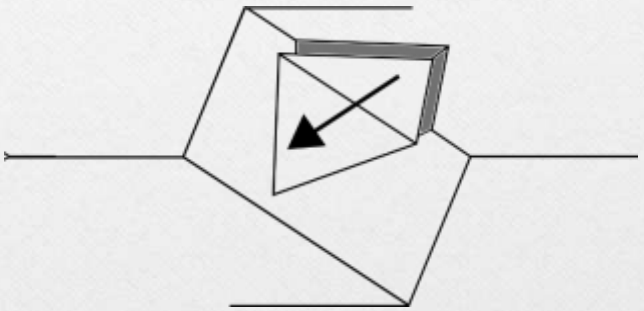


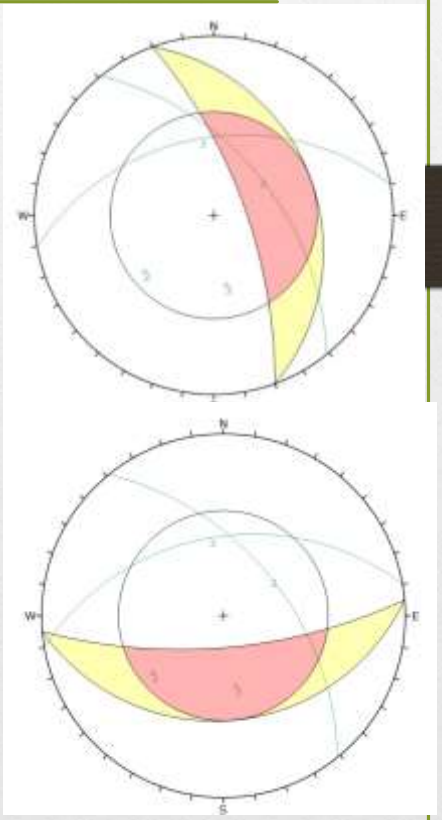
Pole

Stereonet-Based Kinematic Analysis

Wedge failure criteria

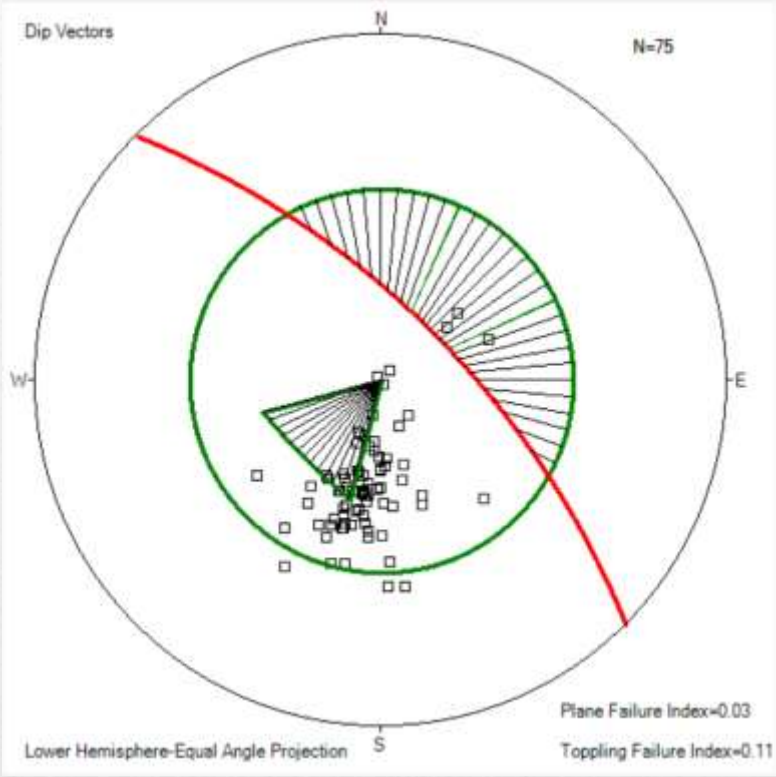






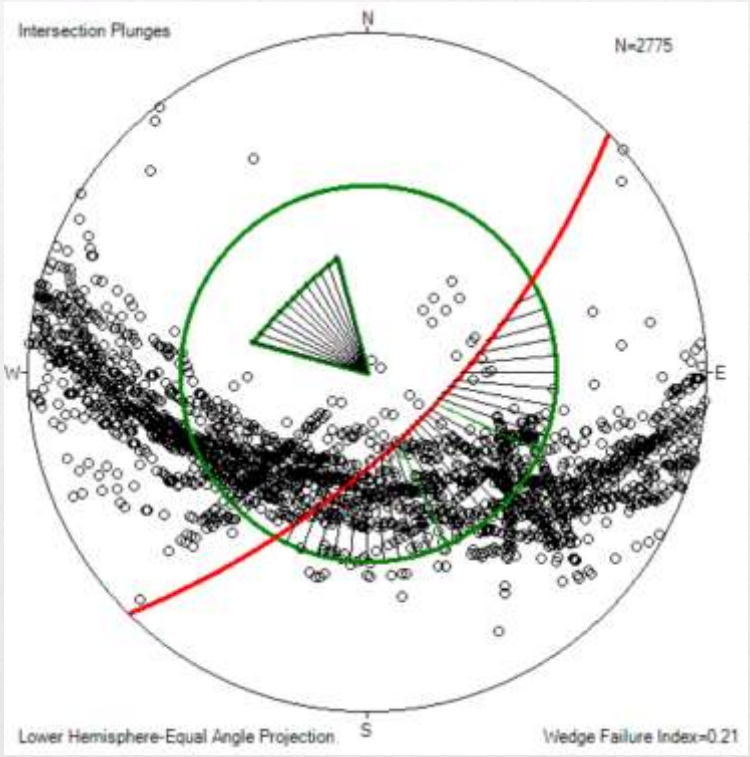
Stereonet-Based Kinematic Analysis

Wedge failure criteria - based on lines of intersections



Stereonet-Based Kinematic Analysis

Wedge failure criteria - based on lines of intersections



Discontinuity Data - Outcrop

Discontinuity Data – Data collection format

Outcrop No.	Lith-ology	Form-ation	Type of disc.	Disc. Set no.	Dip	Dip Dir.	Aperture	Continuity	Water flow	Spacing